decrementing the number of operations of a physical disk unit whose operation has been completed, in accordance with an end of said operation, wherein each of said physical disk units performs requested operations in a queued order, and

wherein said program further comprises referring to a memory storing a table indicating a correspondence of the plurality of physical disk units and said designated logical volume to select single physical disk unit on which said designated logical volume is allocated in accordance with said designation of said designated logical volume by a high-rank apparatus.

REMARKS

In the Office Action mailed April 24, 2001, claims 1, 3-5, 9-11, and 13-16 were rejected under 35 USC 112, first paragraph, claims 1, 3-5, 7, 9-11, and 13-16 were rejected under 35 USC 112, second paragraph, as being indefinite, and claims 1, 3-5, 7, 9-11, and 13-16 were rejected under 35 USC 102(e) as being anticipated by Tanaka et al. (U.S. Patent No. 5,542,064). The foregoing rejection are respectfully traversed.

In accordance with the foregoing, claims 1, 7, 9, 10, 11, 13, 14, 15, and 16 have been amended. A Version with Markings to Show Changes Made is included herewith. Care has been exercised to avoid introduction of new matter.

Claims 1, 3-5, 7, 9-11, and 13-16 are pending and under consideration.

The foregoing rejections of claims 1, 3-5, 9-11, and 13-16 under 35 U.S.C. 112(1) and 35 U.S.C. 112(2) are respectfully traversed. Figures 16 and 17 of "The RAIDBook" show a RAID Level 0 array (refer to the third paragraph beginning on page 36 of "The RAIDBook"). Pages 45 - 51 of "The RAIDBook" explain that RAID Level 0 refers to disk striping, which is shown in Figure 20 of "The RAIDBook" (page 36). Figure 20 shows chunks 0... of the virtual disk striped across physical disks 0, 1, 2, and 3, consistent with Figure 17 of "The RAIDBook". The present specification, page 8 at lines 23-26 discloses that the present invention corresponds to RAID Level 1, a mirror structure in which the individual logical volumes are doubled. The is consistent with the RAID Level 1 definition presented in "The RAIDBook", pages 52 - 56. More particularly, Figure 22 on page 52 of "The RAIDBook" shows a virtual disk having chunks 0, 1, 2, 3, ... stored on both member disk 0 and member disk 1, consistent with

the recitations of the foregoing claims.

Moreover, claims 1, 7, 10, 11, 13, 14, 15, and 16 are amended to overcome the rejections of same under 35 U.S.C. 112(2).

Withdrawal of the rejections of claims 1, 3-5, 9-11, and 13-16 under 35 U.S.C. 112(1) and 35 U.S.C. 112(2) is respectfully requested.

Claim 9 is amended, and claim 11 is further amended, for clarification.

Moreover, the present invention auto-adjusts loads between the physical disk units (refer to the specification, pages 3 and 4). Claims 1, 7, 13, 14, and 15 are further amended to clarify same.

Tanaka discloses that the object is to enhance the input/output throughput of a secondary storage device having a plurality of storage units (as disclosed in column 2, lines 25-30 of Tanaka), and the method for attaining this object is to "select storage units less in the degree of waiting for processing of input/output commands as a group of storage units to be subjected to multiple writing of identical data in a secondary storage device having a plurality of storage units", as disclosed in column 2, lines 54-60 of Tanaka. However, both the "selecting" step and the "accessing" step of Tanaka are different from that "selecting" and "accessing" in the present invention. The "selecting" step and the "accessing" step of Tanaka are disclosed in column 7, beginning at line 65, and following through to the end of column 8 of Tanaka.

More particularly, as disclosed in the foregoing section of Tanaka, in steps S605 and S610, idle disk drives having the requested data are selected. Steps S620 and S625 select plural disk drives having the objective data, unless the number of the selected disk drives reaches the threshold 1 (as disclosed in Tanaka, column 8, lines 31-37).

In S630 of Tanaka, a number of output commands are generated corresponding to the number of the selected disk drives. In steps S635-S645, when a report of achieving a connection to one of the disk drives 16-1 to 16-n receiving output commands output commands of disk drives except the first connected disk drive are cancelled. That is, the selecting and accessing steps in Tanaka show how to select "less waiting" disk drives and to output commands to the "less waiting" plural disk drives and to connect the first-connected single disk drive. In contrast, the present inventions selects the single disk drive which has a minimum number of operations and outputs commands to the single minimum waiting disk drive.

Each of independent claims 1, 7, 13, 14, 15, and 16 recites (using the recitation of claim 1 as an example) "selects the single physical disk unit which has a minimum number of

operations" and "to select said single physical disk unit on which said designated logical volume is allocated in accordance with said designation of said designated logical volume by a high-rank apparatus".

Dependent claims 3-5 and 9-11 recite patentably distinguishing features of their own. For example, claim 3 (depending from claim 1) recites ""a resource manager circuit determining one of the plurality of physical disk units to be accessed in accordance with said number of operations in said memory in response to a transfer request from said channel adapter circuit, and requesting said device adapter circuit to perform an operation accessing said determined physical disk unit".

Withdrawal of the foregoing rejections of claims 1, 3-5, 7-11, and 13-16 as being anticipated by Tanaka et al. is respectfully requested.

If there are any formal matters remaining after this response, the Examiner is requested to telephone the undersigned to attend to these matters.

If there are any additional fees associated with filing of this Amendment, please charge the same to our Deposit Account No. 19-3935.

Respectfully submitted,

STAAS & HALSEY LLP

Date: July 24, 2001

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Please AMEND the following claims:

1. (FIVE TIMES AMENDED) A RAID apparatus comprising:

a plurality of physical disk units storing a plurality of copies of each of logical volumes; and

a disk controller accessing any of the physical disk units which stores a designated logical volume to thereby access said designated logical volume,

said disk controller including:

a memory storing the number of operations requested to each physical disk unit, for each physical disk unit, and

control means for accessing one of said plurality of physical disk units which stores the designated logical volume, in accordance with said number of operations,

wherein said control means compares numbers of operations corresponding to a plurality of physical disk units which store said designated logical volume with each other, and selects the single physical disk unit which has a minimum number of operations,

wherein said control means increments the number of operations of said designated physical disk unit in accordance with a request for said operation and decrements the number of operations of a physical disk unit whose operation has been completed, in accordance with an end of said operation,

wherein each of said physical disk units performs requested operations in a queued order, and

wherein said memory stores a table indicating a correspondence of the plurality of physical disk units and said designated logical volume; and said control means refers to said memory with said designated logical volume to select [a] said single physical disk unit on which said designated logical volume is allocated in accordance with said designation of said designated logical volume by a high-rank apparatus.

3. (AS TWICE AMENDED) The RAID apparatus according to claim 1, wherein said control means includes:

a channel adapter circuit performing interface control with said high-rank apparatus;

a device adapter circuit accessing said physical disk units in accordance with a requested operation; and

a resource manager circuit determining one of the plurality of physical disk units to be accessed in accordance with said number of operations in said memory in response to a transfer request from said channel adapter circuit, and requesting said device adapter circuit to perform an operation accessing said determined physical disk unit.

4. (AS ONCE AMENDED) The RAID apparatus according to claim 3, wherein said resource manager circuit increments a number of operations of said determined physical disk unit in accordance with the request for said operation and decrements the number of operations of the physical disk unit whose operation has been completed, in accordance with the end of said operation of said device adapter circuit.

5. (AS ONCE AMENDED) The RAID apparatus according to claim 3, wherein said memory stores status information indicating statuses of said physical disk units; and

said resource manager circuit refers to said status information to determine whether those physical disk units which store said designated logical volume are normal and selects a normal physical disk unit.

7. (FOUR TIMES AMENDED) An access control method for a RAID apparatus comprising a plurality of physical disk units storing a plurality of copies of each of logical volumes, and a disk controller accessing any physical disk unit which stores a designated logical volume to thereby access said designated logical volume, said method comprising:

determining a plurality of physical disk units which store a designated logical volume; and

selecting one of said determined physical disk units in accordance with the number of operations requested to said physical disk units, said selecting comprising:

comparing said numbers of operations of a plurality of physical disk units which store said designated logical volumes with each other,

accessing the single physical disk unit which has a minimum number of operations,

incrementing the number of operations of said accessed physical disk unit in accordance with a request for said operation, and

decrementing the number of operations of a physical disk unit whose operation has been completed, in accordance with an end of said operation,

wherein each of said plurality of physical disk units performs requested operations in a queued order, and

wherein said selecting further comprises referring to [said] a memory storing a table indicating a correspondence of the plurality of physical disk units and [said logical volume with] said designated logical volume to select a physical disk unit on which said designated logical volume is allocated in accordance with said designation of said designated logical volume by a high-rank apparatus.

9. (THRICE AMENDED) The access control method according to claim 7, wherein said determining step determines said plurality of physical disk units in response to a transfer request from said high-rank apparatus; and

said selecting [step] includes:

requesting an operation for accessing said physical disk unit determined in accordance with said number of operations, and

accessing said physical disk unit in accordance with said requested operation.

10. (TWICE AMENDED) The access control method according to claim 9, wherein the number of operations of said determined physical disk unit is stored in [a] said memory, and a memory location at which the number of operations is stored is incremented in accordance with the request for said operation and is decremented in accordance with the number of operations of the physical disk unit whose operation has been completed, in accordance with an end of said operation of said physical disk unit.

11. (TWICE AMENDED) The access control method according to claim 7, wherein said selecting [step] includes:

referring to status information to determine indicative of statuses of said physical disk units, stored in [a] said memory, to determine whether those physical disk units which form said [identified] designated logical volume are normal; and

selecting a normal physical disk unit.

13. (FOUR TIMES AMENDED) A RAID apparatus comprising:

physical disk units storing redundant logical volumes, a first of the redundant logical volumes being stored on one of the physical disk units, and a second of the redundant logical volumes being stored on another of the physical disk units; and

a disk controller counting numbers of operations respectively requested of each of the physical disk units and accessing one of the first and the second of the redundant logical volumes based on a minimum number of the numbers of operation respectively requested of each of the physical disk units,

wherein said disk controller increments the number of operations of an accessed physical disk unit in accordance with a request for said operation and decrements the number of operations of an accessed physical disk unit whose operation has been completed, in accordance with an end of said operation,

wherein each of said physical disk units performs requested operations in a queued order, and

wherein said disk controller refers to a table indicating a correspondence of the plurality of physical disk units and one of said redundant logical [volume] volumes with said designated logical volume to select [a] single physical disk unit on which said one of said redundant logical [volume] volumes is allocated in accordance with said designation of said one of said redundant logical [volume] volumes by a high-rank apparatus.

14. (THRICE AMENDED) A RAID controller accessing one of a plurality of physical disk units storing a plurality of copies of each of logical volumes to thereby access a designated logical volume, comprising:

a memory storing a number of operations requested to each physical disk unit corresponding to each physical disk unit; and

a controller comparing said numbers of operations corresponding to a plurality of physical disk units which store said designated logical volume with each other, and selecting single one of said plurality of physical disk units which has a minimum number of operations,

wherein said controller increments the number of operations of said selected physical disk unit in accordance with a request for said operation and decrements the number of operations of a physical disk unit whose operation has been completed, in accordance with an end of said operation, wherein each of said plurality of physical disk units performs requested operations in a queued order, and

wherein said memory stores a table indicating a correspondence of the plurality of physical disk units and said designated logical volume; and said controller refers to said memory with said designated logical volume to select a physical disk unit on which said designated logical volume is allocated in accordance with said designation of said designated logical volume by a high-rank apparatus.

15. (THRICE AMENDED) A balancing access method for a RAID apparatus comprising a plurality of physical disk units storing a plurality of copies of each of logical volumes, comprising:

comparing numbers of operations of a plurality of physical disk units which store a designated logical [volumes] volume with each other;

selecting single one of said physical disk units which has a minimum number of operations;

incrementing the number of operations of said accessed physical disk unit in accordance with a request on said operation; and

decrementing the number of operations of a physical disk unit whose operation has been completed, in accordance with an end of said operation, wherein each of said physical disk units performs requested operations in a queued order, and

wherein said selecting further comprises referring to [said] a memory storing a table indicating a correspondence of the plurality of physical disk units and [said logical volume with] said designated logical volume to select [a] said single physical disk unit on which said

designated logical volume is allocated in accordance with said designation of said designated logical volume by a high-rank apparatus, and wherein said balancing access method auto-adjusts loads between the physical disk units.

16. (THRICE AMENDED) A storage medium of a RAID apparatus storing a program, said program which when executed by a computer causes the computer to execute processes comprising:

comparing numbers of operations of a plurality of physical disk units which store a designated logical [volumes] volume with each other;

accessing one of said physical disk units which has a minimum number of operations:

incrementing the number of operations of said accessed physical disk unit in accordance with a request on said operation: and

decrementing the number of operations of a physical disk unit whose operation has been completed, in accordance with an end of said operation, wherein each of said physical disk units performs requested operations in a queued order, and

wherein said program further comprises referring to [said] a memory storing a table indicating a correspondence of the plurality of physical disk units and [said logical volume with] said designated logical volume to select [a] single physical disk unit on which said designated logical volume is allocated in accordance with said designation of said designated logical volume by a high-rank apparatus.